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Addendum 18: Global technical regulation No. 18

Global technical regulation on the measurement procedure for two- or three-wheeled motor vehicles with regard to on-board diagnostics

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Global technical regulation on the measurement procedure for two- or three-wheeled motor vehicles with regard to on-board diagnostics

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I. Statement of technical rationale and justification

A. Introduction

1. The industry producing two- and three-wheeled vehicles in the scope of this global technical regulation (gtr) is a global one, with companies selling their products in many different countries. The Contracting Parties to the 1998 Agreement have determined that work should be undertaken to address the environmental and propulsion unit performance requirements of two- and three-wheeled light motor vehicles, among others as a way to help improve air quality internationally. Currently, the gtr is directed at harmonizing On-Board Diagnostic requirements (OBD) for two- and three-wheeled vehicles, similar as targeted with gtr No. 5 for heavy duty vehicles. This common set of agreed rules in the area of OBD allows the Contracting Parties to realize their own domestic objectives and to pursue their own levels of priorities. Nonetheless, as discussed in more detail below, the gtr has been structured in a manner that facilitates a wider application of OBD to other vehicle systems and objectives in the future.

2. This gtr establishes harmonized functional requirements for OBD and a procedure to test and verify the environmental OBD functions (test type VIII). The functional requirements and test procedures were developed so that they would be:

(a) Able to provide an internationally harmonized set of functional OBD requirements with respect to the "infra-structure" on-board of a vehicle in the scope of this gtr, which determines hardware and software design in a technology neutral way and that considers technical feasibility and cost-effectiveness, such as:

(i) Minimum monitoring requirements of electric and electronic circuits and failure mode detection as well as for monitoring of the control module(s) within the scope of OBD stage I set out in Table 2 of Annex 2;

(ii) Provisions regarding diagnostic trouble codes, diagnostic signals and connection interfaces;

(iii) Provisions regarding access to OBD information which is needed as input to the repair process of a broken vehicles.

(b) Allowing referencing of international technical standards already established for other vehicle types with a proven track record of providing clarity for the design and configuration of the OBD system;

(c) Able to provide an internationally harmonized set of tests to ensure efficient and practicable testing;

(d) Corresponding to state of the art testing technology, allowing to simulate failures where technically feasible;

(e) Applicable in practice to existing and foreseeable future powertrain technologies;

(f) Definition of propulsion unit families with regards to OBD.

3. The gtr also covers harmonized requirements to conduct the environmental verification test procedure (test type VIII) relating to OBD, which is a test procedure by simulating a failure of an emission relevant component in the powertrain management system and its emission control system. Subsequently the OBD system reaction and

containment of the failure is monitored and reported during type I tailpipe emission verification tests.

4. OBD stage I should not oblige manufacturers to change or add fuelling or ignition hardware and should not impose fitting of an electronic carburettor, electronic fuel injection or electronically controlled ignition coils, providing the vehicle complies with the applicable environmental performance requirements. Compliance with the OBD stage I requirements implies that if fuel delivery, spark delivery or intake air hardware is electronically controlled by electric and/or electronic circuits as well as by a dedicated control module, the applicable input or output circuits of that control module need to be monitored, limited to the items and failure modes listed in Table 2 of Annex 2.

5. In the case of a mechanical carburettor fitted with a throttle position sensor providing a circuit signal as input to the PCU / ECU to determine the engine load, which on its turn would be used to electronically control spark delivery, requires monitoring of that throttle position sensor circuit. Also other sensors or actuator circuits listed in Table 2 of Annex 2 shall be monitored although not directly used to control fuel delivery, spark delivery or intake air control. An example of such a case would be the wheel speed sensor circuits in case the vehicle speed would be calculated in the PCU / ECU from the wheel rotation speeds and which would be used as input to control the environmental performance of the vehicle.

6. This gtr is based on the work of the Informal Working Group (IWG) on Environmental and Propulsion unit Performance Requirements (EPPR) of vehicles, from now on referred to as EPPR IWG, which held its first meeting during the sixty-fifth GRPE in January 2013 and on the initial proposal by the European Union (EU, represented by the European Commission (EC)).

B. Procedural background and future development of the gtr

7. The EU put forward and announced their intention of setting up a working group during the sixty-third and sixty-fourth sessions of the Working Party on Pollution and Energy (GRPE) in January and June 2012, and at the 157th session of the World Forum for Harmonization of Vehicle Regulations (WP.29) in June 2012.

8. WP.29 endorsed the proposal (WP.29-158-15) to establish the EPPR IWG under GRPE at its 158th session (13-16th November 2012). The official mandate document is available on the UNECE website with the symbol ECE/TRANS/WP.29/AC.3/36. As this mandate ended by January 2016, the IWG submitted a request to extend the mandate until the end of 2020 (ECE/TRANS/WP.29/2015/113). The Executive Committee of the 1998 Agreement (AC.3) adopted this extension of the mandate at its November 2015 session, which is referred to as ECE/TRANS/WP.29/AC.3/36/Rev.1.

9. At the seventy-third GRPE session in June 2016, a formal proposal of this new gtr was tabled for adoption. Subsequently the proposal was submitted to the November 2016 session of WP.29 for adoption by AC.3.

10. Ongoing developments of test types and procedures and global discussion on harmonization have resulted in the technical requirements contained within this gtr. The final text of the gtr is presented in section II of this document.

C. Existing regulations, directives and international voluntary standards

1. Technical references in the development of the gtr

11. For the development of the gtr, the following legislation and technical standards contain relevant applications of requirements for motorcycles and other vehicles in the scope of this gtr or transferable provisions for passenger cars:

(a) UN (1958 Agreement, light-duty legislation): Chapter 11 of Regulation No. 83;

(b) UN (1998 Agreement, heavy-duty legislation): gtr No. 5;

(c) UN Mutual Resolution No. 2 (M.R.2);

(d) EU: Annex XII to Regulation (EU) No. 44/2014 (Delegated Act on Vehicle Construction Requirements supplementing Regulation (EU) No. 168/2013) with respect to functional OBD requirements, Annex VIII of Regulation (EU) No. 134/2014 (Delegated Act on Environmental and Propulsion Unit Performance supplementing Regulation (EU) No. 168/2013) and Article 21 of Regulation (EU) No. 168/2013;

(e) Japan: Safety Regulations for Road Vehicles, Article 31, Attachment 115;

(f) The United States of America (light-duty legislation): US CFR, Title 40, Part 86, Subpart S;

(g) Standards:

(i) International: ISO 2575, ISO 9141-2, ISO 14229-3, ISO 14229-4, ISO 14230-4, ISO 15031-4, ISO 15031-5, ISO 15031-6, ISO 15765-4, ISO 20828, ISO 22901-2;

(ii) USA: SAE J1850.

2. Methodology for deriving harmonized test procedures for the gtr

12. The European Commission launched an EPPR study for L-category vehicles in January 2012 with the objective to develop proposals to update gtr No. 2 for technical progress and to develop proposals for gtrs and Regulations with respect to harmonized EPPR legislation not yet covered at the international level for two- and three-wheeled vehicles, e.g. crankcase and evaporative emission test requirements, on-board diagnostic requirements, propulsion unit performance requirements, etc. The output of this comprehensive study[1] was submitted for the review and comments of the EPPR IWG with the objective to identify concerns and to provide base proposals ready for further enhancements by the EPPR IWG in order to accommodate the needs at the international level to assess a vehicle with respect to on-board diagnostics in a scientifically based, objective and globally accepted way.

13. The outcome of this work was among others the development of a first draft gtr proposal on OBD based on the consolidation of existing global legislation and up to date technical provisions. After discussions and adopting a number of amendments the EPPR IWG decided to take the EC proposal as a basis for the first draft gtr of the Group. This text then further evolved in many different revisions and was modified in iterative steps to reflect the discussions and decisions by the Group over the period 2013 - 2016.

[1] Document reference EPPR-07- 07

D. Discussion of the issues addressed by the gtr

1. List of issues

14. This gtr brings together the harmonized test procedures with regard to on-board diagnostic requirements for the approval of vehicles in the scope of this gtr. The process to develop this gtr followed the methodology discussed in chapter C.2. where important issues discussed and addressed during the development were, among others:

15. Horizontal issues identified also for other gtrs in the area of EPPR:

(a) Scope;

(b) Reference fuel;

(c) Temperature unit °C versus K.

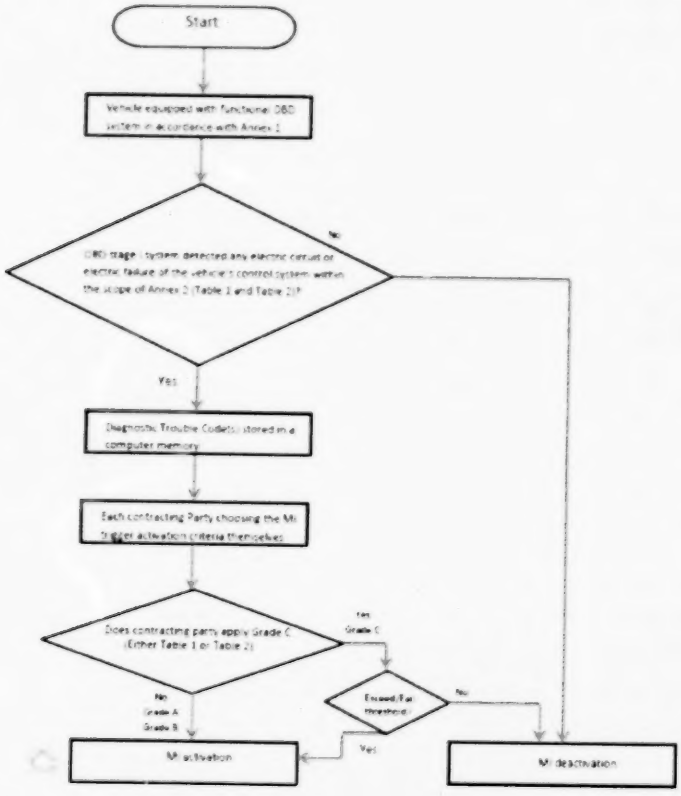
16. Specific issues:

(a) OBD stage I grades A, B and C diagnostic options set out in Table 1 of Annex 2;

(b) Malfunction Indicator (MI) trigger activation criteria:

Figure 1

Flowchart MI trigger activation criteria


Start
Vehicle equipped with functional OBD system in accordance with Annex 1
OBD stage I system detected any electric circuit or electric failure of the vehicle's control system within the scope of Annex 2 (Table 1 and Table 2)?
No
Yes
Diagnostic Trouble Code(s) stored in a computer memory
Each contracting Party choosing the MI trigger activation criteria themselves
Does contracting party apply Grade C (Either Table 1 or Table 2)
Yes
Grade C
Exceed Set threshold
No
No
Grade A
Grade B
Yes
MI activation
MI deactivation

(c) Need for a review clause for Table 2 in Annex 2 to update the list for technical progress in due course;

(d) The effect of OBD stage I on propulsion unit hard- and software design. The EPPR IWG decided that OBD stage I should not oblige manufacturers to change or add fuelling or ignition hardware and should not impose fitting of an electronic carburettor, electronic fuel injection or electronically controlled ignition coils, providing the vehicle complies with the applicable environmental performance requirements.

2. Applicability

17. The EPPR IWG, as agreed upon in the terms of reference, has prepared a gtr for vehicles in the scope of this gtr under the 1998 Agreement as well as two- or three-wheeled vehicles under the 1958 Agreement. In accordance with the agreed terms of reference of gtrs and Regulations in the area of EPPR will be developed as much as possible in a coherent way.

3. Scope

18. The EPPR IWG has discussed at length which vehicle types should be in the scope of the gtr. One of the objectives of the Group was to discuss the substantive requirements of two-wheeled vehicles first followed by a discussion if these requirements should as well be applied to three-wheeled vehicles. In particular it was debated whether or not the classification criteria laid down in paragraph 2. of Special Resolution No. 1 (S.R.1) on category 3 vehicles should be referenced in detail or using a more generic wording, e.g. two- and three-wheeled vehicles or motorcycles allowing for more flexibility to allow alignment with domestic classification of three-wheeled vehicles.

19. The EPPR IWG discussed possible solutions how three-wheeled vehicles could be included in the scope of the gtr given the fact that S.R.1 contains recommended classification criteria for category 3 vehicles that might require an update for technical progress. Finally it was agreed to put "category 3" motorcycles in paragraph 2. of the gtr, to reference S.R.1 in a footnote and to state the following with respect to the classification of a three-wheeled vehicle:

"With regard to a three-wheeled vehicle of category 3-4 or 3-5, Contracting Parties agree that at a minimum the following criteria should be taken into account for vehicle classification:

(a) In their straight-ahead condition, motor vehicles having two wheels which are placed on the same straight line and equipped with one sidecar; or,

(b) Motor vehicles having a saddle-type seat, a handle-bar type steering system and three wheels, on which the side of the driver's seat is of open structure."

20. Contracting Parties may expand the scope to other types of three-wheeled vehicles in order to align with their domestic classifications of three-wheeled vehicles as deemed appropriate.

4. Definitions

21. The definitions used in the gtr are aligned as much as possible with definitions in international legislation and from the work of the Vehicle Propulsion System Definitions (VPSD) Group operating under GRPE with the goal to harmonize high level powertrain definitions as well as from other regional legislation as listed in chapter C.1. The definitions set out in Mutual Resolution No. 2 were re-used where possible in this gtr.

22. In the definition of "useful life" a reference to a period of time has been included as proposed by Japan, because of the following reasons:

(a) Firstly, the general life cycle for industrial products is prescribed by its life period, so the time is the necessary parameter to define the life cycle. For instance, if a vehicle with the product warranty for "ten years and total mileage of one-hundred-thousand kilometres" has only one kilometre as total mileage but is 20-years old, the vehicle should not be regarded as in-warranty.

(b) Secondly, the definition in the gtr on crankcase and evaporative emissions is also referring to the period of distance and time.

5. Requirements

23. Regarding functional requirements for OBD, the gtr contains the following main items:

(a) Minimum monitoring requirements for OBD stage I;

(b) Provisions regarding design of the Malfunction Indicator (MI), diagnostic trouble codes, diagnostic signals and connection interfaces;

(c) Provisions regarding access to OBD information;

(d) Definition of propulsion unit families with regard to OBD.

24. Regarding the environmental test procedure for OBD, the gtr contains the elements:

(a) Test vehicle requirements;

(b) Test procedure by simulating failure of exhaust emission relevant components in the powertrain management system and emission control system and monitoring the OBD system reaction during a type I test cycle;

(c) Failure modes to be tested for OBD stage I.

25. Minimum administrative requirements have been set out to reflect the technical requirements addressed in this gtr.

6. Performance requirements

26. The performance requirements are not harmonized yet and are applicable as specified by the Contracting Parties in accordance with the flow chart in Figure 1, in chapter D.1. The reason that it has not been possible to harmonize the performance requirements was mainly been that there was no agreement reached in the IWG on the objectives of on-board diagnostics for two-and three-wheeled motor vehicles. Nevertheless the IWG was able to come up with the largest possible common denominator in the harmonized OBD requirements, which nevertheless support the domestic objectives from the Contracting Parties. It is anticipat.d that eventually in the future when further developing the gtr and supplementing it with OBD stage II requirements there might be more common grounds found to also harmonize the performance requirements. Up to that point the MI will be activated in accordance with the flow chart in Figure 1, in chapter D.1.

7. Reference fuel

27. The reference fuel shall be specified and selected by the Contracting Parties as deemed appropriate and is not harmonized yet either. However it is strongly recommended to use the same test fuel specification for type VIII environmental OBD verification testing

as was used for type I tailpipe emissions after cold start testing and for tailpipe emissions verification testing as part of test type V durability of pollution control devices.

8. Regulatory impact and economic effectiveness

28. Increasingly two- and three-wheeled vehicles in the scope of this gtr are being designed for the world market. To the extent that manufacturers are preparing substantially different models in order to meet different emission regulations and methods of measuring CO_2 emission and fuel or energy consumption, testing costs and other production values are increased. It would be more economically efficient to have manufacturers use a similar test procedure worldwide wherever possible to prove satisfactory performance before being placed on the market. A prerequisite for that is a harmonized definition of the test procedures with respect to on-board diagnostics. It is anticipated that the test procedures in this gtr will provide a common test programme for manufacturers to use in countries worldwide and thus reduce the amount of resources utilised to test vehicles in the scope of this gtr. These savings will accrue not only to the manufacturers, but more importantly, to the consumers and the authorities as well.

9. Potential cost effectiveness

29. At the time of writing this revision of the gtr, the data is not available to undertake a full impact assessment of the test procedures contained. Specific cost effectiveness values in markets around the globe can be quite different, depending on the national or regional market situation. While there are no calculated values here, the belief of the EPPR IWG is that there are clear and significant benefits comparing to low anticipated cost increases associated with this gtr.

II. Text of the global technical regulation

1. Purpose

1.1. This gtr prescribes the requirements for On-Board Diagnostic (OBD) systems to detect, and, if applicable, record and/or communicate failures of specific vehicle and engine systems that affect the environmental performance of these systems, as described in the specific annexes to this gtr.

1.2. In addition, this gtr specifies the elements concerning the OBD system to facilitate the diagnosis, efficient and effective repair and maintenance of specific vehicle and engine systems without containing mandatory prescriptions for this purpose.

1.3. OBD stage I should not oblige manufacturers to change or add fuelling or ignition hardware and should not impose fitting of an electronic carburettor, electronic fuel injection or electronically controlled ignition coils, providing the vehicle complies with the applicable environmental performance requirements. Compliance with the OBD stage I requirements implies that if fuel delivery, spark delivery or intake air hardware is electronically controlled, the applicable input or output circuits need to be monitored, limited to the items and failure modes listed in Table 2 of Annex 2.

1.4. The Malfunction Indicator (MI) design will be harmonized in OBD stage I but the MI activation performance criteria are prescribed as two alternative grades A or B set out in Table 1 of Annex 2. Consequently, each Contracting Party is free to choose from these alternatives. In addition, a Contracting Party may opt for the elements attributed to enhanced diagnostics (grade C) set out in Table 1 of Annex 2.

2. Scope and application

Two- and three-wheeled vehicles of category 3[1] equipped with a propulsion unit in accordance with Table 1.

[1] ECE/TRANS/WP.29/1045, as amended by Amends. 1 and 2 (Special Resolution No. 1, www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29resolutions.html)

Table 1

Scope with regard to the propulsion unit and fuel type

Propulsion unit and fuel type				*Functional OBD*	*Test type VIII (1)*
Vehicle with PI engine	Mono-fuel*	Petrol		Yes	
		LPG		Yes	
		NG / Biomethane		Yes	
	Bi-fuel	Petrol	LPG	Yes	
		Petrol	NG / Biomethane	Yes	
		Petrol	Hydrogen	Yes	
	Flex-fuel	Petrol	Ethanol (E85)	Yes	
		NG / Biomethane	HCNG	Yes	(2)
Vehicle with CI engine	Flex-fuel	Diesel	Bio-Diesel	Yes	(3)
	Mono-fuel	Diesel		Yes	
Pure electric vehicle or vehicle propelled with Compressed Air (CA)				No	No
Hydrogen Fuel cell vehicle				No	No

(1) At the discretion of the Contracting Party

(2) NG/Biomethane only, at the discretion of the Contracting Party

(3) B5 only, at the discretion of the Contracting Party

*Exemption: OBD requirements are exempted in petrol mode of a mono-fuel motor vehicle that is designed primarily for permanent running on LPG or NG / bio-methane or hydrogen, having a petrol system, with a petrol fuel tank capacity not exceeding two litres in the case of two-wheeled motorcycles and motorcycles with sidecar and not exceeding three litres in the case of three-wheeled vehicles, intended for emergency purposes or starting only.

3. Definitions

The definitions set out in gtr No. 2 shall apply. In addition, the following definitions shall apply in this gtr:

2.1. "*Access to OBD*" means the unrestricted availability of the on-board diagnostic information laid down in this gtr via the serial interface for the standard diagnostic connection, pursuant to paragraph 3.12. of Annex 1;

3.2. "*Calculated load value*" refers to an indication of the current airflow divided by peak airflow, where peak airflow is corrected for altitude, if available.[2] This definition provides a dimensionless number that is not engine-specific and provides the service technician with an indication of the proportion of engine capacity being used (with wide open throttle as 100 per cent);

[2] Other variables prescribed in paragraph 3.1.3. of Annex 1 are also permitted.

3.3. "*Calibration*" of the powertrain / engine or drive train control unit means the application specific set of data maps and parameters used by the control unit's software to tune the vehicle's powertrain / engine or drive train;

3.4. "*Communication protocol*" means a system of digital message formats and rules for exchanging those messages in or between computing systems or units;

3.5. "*Control system*" means the electronic engine management controller and any component referred to in this gtr which supplies an input to or receives an output from this controller;

3.6. "*Default mode*" refers to a case where the engine management controller switches to a setting that does not require an input from a failed component or system;

3.7. "*Deficiency*" in respect of vehicle OBD systems, means a situation in which up to two separate components or systems that are monitored contain temporary or permanent operating characteristics that impair their otherwise efficient OBD monitoring or do not meet all other detailed requirements for OBD;

3.8. "*Driving cycle*" means a test type I cycle consisting of engine start-up, driving mode where a malfunction would be detected if present, and engine shut-off;

3.9. "*Limp-home*" means an operation mode triggered by the control system that restricts fuel quantity, intake air quantity, spark delivery or other powertrain control variables resulting in significant reduction of output torque or engine revolution or vehicle speed;

3.10. "*Malfunction Indicator (MI)*" means a visible indicator that clearly informs the driver of the vehicle in the event of malfunctions;

3.11. "*Malfunction*" means the failure of an electric /electronic circuit referred to in this gtr;

3.12. "*On-Board Diagnostic system (OBD)*" means an electronic system fitted on-board of a vehicle that has the capability of identifying the likely area of malfunction by means of fault codes stored in a computer memory which can be accessed by means of a generic scan tool;

3.13. "*Permanent default mode*" refers to a case where the engine management controller permanently switches to a setting that does not require an input from a failed component or system;

3.14. "*Power take-off unit*" means an engine-driven output provision for the purposes of powering ancillary, vehicle-mounted equipment;

3.15. "*Repair information*" means all information required for diagnosis, servicing, inspection, periodic monitoring or repair of the vehicle and which the manufacturers provide for their authorized dealers/repair shops or for manufacturers of replacement or retrofit components which are compatible with the vehicle OBD system. Where necessary, such information shall include service handbooks, technical manuals, diagnosis information (e.g. minimum and maximum theoretical values for measurements), wiring diagrams, the software calibration identification number applicable to a vehicle type, instructions for individual and special cases, information provided concerning tools and equipment, data record information and bi-

directional monitoring and test data as specified in paragraph 3.8. of Annex 1. The manufacturer shall also make accessible, where appropriate on payment, the technical information required for the repair or maintenance of motor vehicles unless that information is covered by an intellectual property right or constitutes essential, secret know-how which is identified in an appropriate form; in such case, the necessary technical information shall not be withheld improperly;

3.16. "*Software*" of the powertrain / engine or drive train control units means a set of algorithms concerned with the operation of powertrain, engine or drive train data processing systems, containing an ordered sequence of instructions that change the state of the powertrain, engine or drive train control unit;

3.17. "*Standardised data*" means that all data stream information, including all diagnostic trouble codes used, is produced only in accordance with industry standards which, by virtue of the fact that their format and their permitted options are clearly defined, provide for a maximum level of harmonization in the industry developing and producing vehicles in the scope of this gtr, and the use of which is expressly permitted in this Regulation;

3.18. "*Unrestricted access to the OBD system*" means:

(a) Access not dependent on an access code obtainable only from the manufacturer, or a similar device; or

(b) Access allowing evaluation of the data produced without the need for any unique decoding information, unless that information itself is standardised information.

3.19. "*Useful life*" means the relevant period of distance and/or time over which compliance with the OBD system has to be assured.

3.20. "*Warm-up cycle*" means sufficient vehicle operation such that the coolant temperature rises by at least 22 °C from engine start-up to at least 70 °C. If this condition is insufficient to determine the warm up cycle, with the permission of the approval authority, alternative criteria and/or alternative signal(s) or information (e.g. spark plug seat temperature, engine oil temperature, vehicle operation time, accumulative engine revolution, travel distance, etc.) may be adopted. In any case, all signal(s) and information used for determination need to be monitored by the ECU and shall be made available by data stream.

4. List of acronyms and symbols

Table 2
List of acronyms and symbols

Item	*Unit*	*Term*
APS	-	accelerator (pedal / handle) position sensor
CAN	-	controller area network
CARB	-	California air resources board
CI	-	compression ignition engine

Item	*Unit*	*Term*
CO_2	g/km	carbon dioxide
DTC		diagnostic trouble code
E85	-	ethanol blended petrol, up to 85% Ethanol
ECU	-	engine control unit
EPA	-	environmental protection agency, at USA federal level
ETC	-	electronic throttle control
HCNG	-	hydrogen-compressed natural gas mixtures
ID	-	identifier
ISO	-	international standardisation organisation
LPG	-	liquefied petroleum gas
MI	-	malfunction indicator
NG	-	natural gas
ODX	-	open diagnostic data exchange
PCU	-	powertrain control unit
PI	-	positive ignition engine
PID	-	parameter identifier
SAE	-	society of automotive engineers, USA based globally active standardisation organisation
Test type I	-	test of tailpipe emissions after cold start
Test type V	-	test of durability of the vehicle's pollution control devices, mix of distance accumulation and test type I verification testing
Test type VIII	-	special test type I with induced fault mode to assess the impact on the tailpipe emission performance of a vehicle
TPS	-	throttle (accelerator actuator) position sensor
UDS	-	unified diagnostic services
VIN	-	vehicle identification number

5. General requirements

5.1. Vehicles, systems, and components shall be so designed, constructed and assembled by the manufacturer, so as to enable the vehicle, in normal use and maintained according to the prescriptions of the manufacturer, to comply with the provisions of this gtr during its useful life.

5.2. OBD stage I

5.2.1. The technical requirements of this section shall be mandatory for vehicles in the scope of this gtr equipped with an OBD stage I system.

5.2.2. The OBD stage I system shall monitor for any electric circuit and electronics failure of the vehicle's control system laid down in Annex 2.

5.2.3. Electric circuit diagnostic

5.2.3.1. For the purposes of paragraph 5.2.4.3.3. the electric circuit and electronic failure diagnostics with regard to OBD stage I shall at a minimum contain the sensor and actuator diagnostics as well as the internal diagnostics of the electronic control units required in Annex 2.

5.2.4. Functional OBD requirements

5.2.4.1. Vehicles in the scope of this gtr shall be equipped with an OBD stage I system so designed, constructed and installed in a vehicle as to enable it to identify types malfunction over the useful life of the vehicle.

5.2.4.1.1. Access to the OBD system required for the inspection, diagnosis, servicing or repair of the vehicle shall be unrestricted and standardised. All OBD relevant diagnostic trouble codes shall be consistent with paragraph 3.11. of Annex 1.

5.2.4.1.2. At the manufacturer's discretion, to aid technicians in the efficient repair of vehicles, the OBD system may be extended to monitor and report on any other on-board system. Extended diagnostic systems shall not be considered as falling under the scope of approval requirements.

5.2.4.2. The OBD system shall be so designed, constructed and installed in a vehicle as to enable it to comply with the requirements of this gtr during conditions of normal use.

5.2.4.2.1. Temporary disablement of the OBD system

5.2.4.2.1.1. A manufacturer may disable the OBD system at ambient engine starting temperatures below -7°C or at elevations over 2.500 metres above sea level, provided it submits data or an engineering evaluation which adequately demonstrate that monitoring would be unreliable in such conditions. It may also request disablement of the OBD system at other ambient engine starting temperatures if it demonstrates to the authority with data or an engineering evaluation that misdiagnosis would occur under such conditions.

5.2.4.2.1.2. For vehicles designed to accommodate the installation of power take-off units, disablement of affected monitoring systems is permitted provided disablement occurs only when the power take-off unit is active.

5.2.4.2.1.3. The manufacturer may temporarily disable the OBD system in the following conditions:

(a) For flex-fuel or mono/bi-fuel gas vehicles for one minute after re-fuelling to allow for the recognition of fuel quality and composition by the Powertrain Control Unit(s) (PCU);

(b) For bi-fuel vehicles for five seconds after fuel switching to allow for engine parameters to be readjusted;

(c) The manufacturer may deviate from these time limits if it can be demonstrated that stabilisation of the fuelling system after re-fuelling or fuel switching takes longer for justified technical reasons. In any case, the OBD system shall be re-enabled as soon as either the fuel quality or composition is recognised or the engine parameters are readjusted.

5.2.4.3. The OBD system shall monitor for:

5.2.4.3.1. At a minimum the electric / electronic circuits required in Annex.2.

5.2.4.3.2. If active on the selected fuel, other emission control system components or systems, or emission-related powertrain components or systems, which are connected to a computer.

5.2.4.3.3. Unless otherwise monitored, any other electronic powertrain component connected to a computer relevant including any relevant sensors to enable monitoring functions to be carried out, shall be monitored for electric / electronic circuit failures. In particular, these electronic components shall be continuously monitored for any electric circuit continuity failure, shorted electric circuits, electric range / performance and stuck signal of the control system in accordance with Annex 2.

5.2.4.4. A sequence of diagnostic checks shall be initiated at each engine start and completed at least once provided that the correct test conditions are met.

5.2.4.5. Activation of the Malfunction Indicator (MI)

5.2.4.5.1. The OBD system shall incorporate a malfunction indicator readily perceivable to the vehicle operator. The MI shall not be used for any purposes other than to indicate emergency start-up or limp-home routines to the driver. The MI shall be visible in all reasonable lighting conditions. When activated, it shall display a symbol in conformity with ISO 2575:2010, symbol F.01. A vehicle shall not be equipped with more than one general purpose MI used to convey power-train related failures which may affect emissions. Separate specific purpose tell tales (e. g. brake system, fasten seat belt, oil pressure, etc.) are permitted. The use of red colour for a MI is prohibited.

5.2.4.5.2. For strategies requiring more than two preconditioning cycles for MI activation, the manufacturer shall provide data or an engineering evaluation which adequately demonstrate that the monitoring system is equally effective and timely in detecting component deterioration. Strategies requiring on average more than ten driving cycles for MI activation are not accepted.

5.2.4.5.3. The MI shall also activate when the vehicle's ignition is in the "key-on" position before engine starting or cranking and deactivate if no malfunction has been detected. For vehicles not equipped with a battery, the MI shall illuminate immediately after engine starting and shall subsequently be deactivated after 5 seconds, if no malfunction has previously been detected.

5.2.4.6. The OBD system shall record diagnostic trouble code(s) indicating the status of the control system. Separate status codes shall be used to identify correctly functioning control systems and those control systems which need further vehicle operation to be fully evaluated. If the MI is activated due to malfunction or permanent default modes of operation, a diagnostic trouble code

shall be stored that identifies the type of malfunction. A diagnostic trouble code shall also be stored in the cases referred to in paragraph 5.2.4.3.3.

5.2.4.6.1. The distance travelled by the vehicle while the MI is activated shall be available at any moment through the serial port on the standardised diagnostic connector. By means of derogation for vehicles equipped with a mechanically operating odometer that does not allow input to the electronic control unit, "distance travelled" may be replaced with "engine operation time" and shall be made available at any moment through the serial port on the standardised diagnostic connector. Engine operation time in this context means the total accumulated time in which the propulsion unit(s) provide(s) mechanical output (e.g. the crankshaft of a combustion engine or electric motor rotates) after triggering the MI activation during one or more key cycles.

5.2.4.7. Extinguishing the MI

5.2.4.7.1. For all malfunctions, the MI may be deactivated after three subsequent sequential driving cycles during which the monitoring system responsible for activating the MI ceases to detect the malfunction and if no other malfunction has been identified that would independently activate the MI.

5.2.4.8. Erasing a diagnostic trouble code

5.2.4.8.1. The OBD system may erase a diagnostic trouble code and the distance travelled and freeze-frame information if the same fault is not re-registered in at least 40 engine warm-up cycles.

5.2.4.8.2. Stored faults shall not be erased by disconnection of the on-board computer from the vehicle power supply or by disconnection or failure of the vehicle battery or batteries.

5.2.4.9. Bi-fuelled gas vehicles

In general, all the OBD requirements applying to a mono-fuelled vehicle apply to bi-fuelled gas vehicles for each of the fuel types (petrol and (NG/biomethane)/LPG)). To this end, one of the following two alternatives in paragraphs 5.2.4.9.1. or 5.2.4.9.2. or any combination thereof shall be used.

5.2.4.9.1. One OBD system for both fuel types

5.2.4.9.1.1. The following procedures shall be executed for each diagnostic in a single OBD system for operation on petrol and on (NG/biomethane)/LPG, either independent of the fuel currently in use or fuel type specific:

(a) Activation of Malfunction Indicator (MI) (see paragraph 5.2.4.5.);

(b) Diagnostic trouble code storage (see paragraph 5.2.4.6.);

(c) Extinguishing the MI (see paragraph 5.2.4.7.);

(d) Erasing a diagnostic trouble code (see paragraph 5.2.4.8.).

For components or systems to be monitored, either separate diagnostics for each fuel type can be used or a common diagnostic.

5.2.4.9.1.2. The OBD system can reside in either one or more computers.

5.2.4.9.2. Two separate OBD systems, one for each fuel type.

5.2.4.9.2.1. The following procedures shall be executed independently of each other when the vehicle is operated on petrol or on (NG/biomethane)/LPG:

(a) Activation of Malfunction Indicator (MI) (see paragraph 5.2.4.5.);

(b) Diagnostic trouble code storage (see paragraph 5.2.4.6.);

(c) Extinguishing the MI (see paragraph 5.2.4.7.);

(d) Erasing a diagnostic trouble code (see paragraph 5.2.4.8.).

5.2.4.9.2.2. The separate OBD systems can reside in either one or more computers.

5.2.4.9.3. Specific requirements regarding the transmission of diagnostic signals from bi-fuelled gas vehicles.

5.2.4.9.3.1. On a request from a diagnostic scan tool, the diagnostic signals shall be transmitted on one or more source addresses. The use of source addresses is set out in ISO 15031-5:2011.

5.2.4.9.3.2. Identification of fuel specific information can be realised as follows:

(a) By use of source addresses;

(b) By use of a fuel select switch;

(c) By use of fuel specific diagnostic trouble codes.

5.2.4.9.4. Regarding the status code (described in paragraph 5.2.4.6.), one of the following two alternatives has to be used if one or more of the diagnostics reporting readiness is fuel type specific:

(a) The status code is fuel specific, i.e. use of two status codes, one for each fuel type;

(b) The status code shall indicate fully evaluated control systems for both fuel types (petrol and (NG/biomethane)/LPG)) when the control systems are fully evaluated for one of the fuel types.

If none of the diagnostics reporting readiness is fuel-type specific, only one status code has to be supported.

5.2.5. Requirements relating to the approval of on-board diagnostic systems

5.2.5.1. A manufacturer may ask the approval authority to accept an OBD system for approval even if the system contains one or more deficiencies so that the specific requirements of this annex are not fully met.

5.2.5.2. In considering the request, the authority shall determine whether compliance with the requirements of this annex is unfeasible or unreasonable.

The authority shall take into consideration data from the manufacturer detailing factors such as, but not limited to, technical feasibility, lead time and production cycles including phase-in or phase-out of engines or vehicle designs and programmed upgrades of computers, the extent to which the resultant OBD system will be effective in complying with the requirements of this Regulation and whether the manufacturer has demonstrated an acceptable level of effort to comply with those requirements.

5.2.5.2.1. The authority shall not accept any deficiency request that includes the complete lack of a required diagnostic monitor.

5.2.5.3. Prior to, or at the time of, approval, no deficiency shall be granted in respect of the requirements of paragraph 3. of Annex 1, except paragraph 3.11. of Annex 1.

5.2.5.4. Deficiency period

5.2.5.4.1. A deficiency may be carried over for a period of two years after the date of approval of the vehicle type unless it can be adequately demonstrated that substantial vehicle hardware modifications and additional lead-time beyond two years would be necessary to correct it. In such a case, it may be carried over for a period not exceeding three years.

5.2.5.4.2. A manufacturer may ask the approval authority to grant a deficiency retrospectively when it is discovered after the original approval. In this case, the deficiency may be carried over for a period of two years after the date of notification to the administrative department unless it can be adequately demonstrated that substantial vehicle hardware modifications and additional lead-time beyond two years would be necessary to correct it. In such a case, it may be carried over for a period not exceeding three years.

5.2.5.5. The authority shall notify all other Contracting Parties of its decision on granting a deficiency request.

5.2.6. Propulsion family definition with regard to OBD and in particular to test type VIII

5.2.6.1. A representative parent vehicle shall be selected to test and demonstrate to the approval authority the functional on-board diagnostic requirements set out in Annex 1 and if applicable to verify the test type VIII requirements laid down in Annex 3 if this is applied by the Contracting Party based on the grade laid down in Table 1 of Annex 2 and the propulsion family definition laid down in Annex 4. All members of the family shall comply with the applicable requirements and performance limits set out in this gtr.

5.2.7. Documentation

The vehicle manufacturer shall complete the information document in accordance with the items listed in Annex 5 and submit it to the approval authority.

Annex 1

Functional aspects of On-Board Diagnostic (OBD) systems

1. Introduction

The on-board diagnostic systems fitted on vehicles in the scope of this gtr shall comply with the detailed information and functional requirements and verification test procedures of this annex in order to harmonize the systems and verify if the system is capable of meeting the functional part of the on-board diagnostic requirements.

2. On-board diagnostic functional verification testing

2.1. If applied by a Contracting Party the on-board diagnostic environmental system performance and the functional OBD capabilities may be verified and demonstrated to the approval authority by performing the type VIII test procedure referred to in Annex 3.

3. Diagnostic signals

3.1. Except in the case of grade A OBD, upon determination of the first malfunction of any component or system, "freeze-frame" engine conditions present at the time shall be stored in computer memory in accordance with the specifications in paragraph 3.10. Stored engine conditions shall include, but are not limited to, calculated load value, engine speed, fuel trim value(s) (if available), fuel pressure (if available), vehicle speed (if available), coolant temperature (if available), intake manifold pressure (if available), closed- or open-loop operation (if available) and the diagnostic trouble code which caused the data to be stored.

3.1.1. Except in the case of grade A OBD, the manufacturer shall choose the most appropriate set of conditions facilitating effective and efficient repairs in freeze-frame storage. Only one frame of data is required. Manufacturers may choose to store additional frames provided that at least the required frame can be read by a generic scan tool meeting the specifications of paragraphs 3.9. and 3.10. If the diagnostic trouble code causing the conditions to be stored is erased in accordance with paragraph 5.2.4.8.1. of section II the stored engine conditions may also be erased.

3.1.2. The calculated load value shall be calculated as follows:

Equation 1:

$$CLV = \frac{Current\_airflow}{Peak\_airflow(at\_sea\_level)} \cdot \frac{Atmospheric\_pressure\_(at\_sea\_level)}{Barometric\_pressure}$$

3.1.3. Alternatively, the manufacturer may choose another appropriate load variable of the propulsion unit (such as throttle position, intake manifold pressure, etc.) and shall demonstrate that the alternative load variable correlates well with calculated load variable set out in paragraph 3.1.2. [and is in accordance with the specifications in paragraph 3.10.].

3.2. Except in the case of grade A OBD, if available, the following signals in accordance with the specifications in paragraph 3.10. in addition to the required freeze-frame information shall be made available on demand through the serial port on the standardised diagnostic connector, if the

information is available to the on-board computer or can be determined using information available to the on-board computer: number of stored diagnostic trouble codes, engine coolant temperature, fuel control system status (closed-loop, open-loop, other), fuel trim, ignition timing advance, intake air temperature, manifold air pressure, air flow rate, engine speed, throttle position sensor output value, secondary air status (upstream, downstream or atmosphere), calculated load value, vehicle speed, the activated default mode(s) and fuel pressure.

The signals shall be provided in standard units based on the specifications in paragraph 3.10. Actual signals shall be clearly identified separately from default value or limp-home signals.

3.3. For all control systems for which specific on-board evaluation tests are conducted as listed in Table 2 of Annex 2 the results of the most recent test performed by the vehicle and the limits to which the system is compared shall be made available through the serial data port on the standardised diagnostic connector according to the specifications in paragraph 3.12. For the monitored components and systems excepted above, a pass/fail indication for the most recent test results shall be available through the standardised diagnostic connector.

3.4. The OBD requirements to which the vehicle is certified and the major control systems monitored by the OBD system in accordance with the specifications in paragraph 3.10. shall be made available through the serial data port on the standardised diagnostic data link connector according to the specifications in paragraph 3.8.

3.5. The software identification and calibration verification numbers shall be made available through the serial port on the standardised diagnostic data link connector. Both numbers shall be provided in a standardised format in accordance with the specifications in paragraph 3.10.

3.6. The diagnostic system is not required to evaluate components during malfunction if such evaluation would result in a risk to safety or component failure.

3.7. The diagnostic system shall provide for standardised and unrestricted access to OBD and conform with the following ISO standards or SAE specification:

3.8. One of the following standards with the restrictions described shall be used as the on-board to off-board communications link:

(a) ISO 9141-2:1994/Amd 1:1996: "Road Vehicles — Diagnostic Systems — Part 2: CARB requirements for interchange of digital information";

(b) SAE J1850: March 1998 "Class B Data Communication Network Interface. Emission related messages shall use the cyclic redundancy check and the three-byte header and not use inter byte separation or checksums";

(c) ISO 14229-3:2012: "Road vehicles — Unified Diagnostic Services (UDS) — Part 3: Unified diagnostic services on CAN implementation";

(d) ISO 14229-4:2012: "Road vehicles — Unified diagnostic services (UDS) — Part 4: Unified diagnostic services on FlexRay implementation";

(e) ISO 14230-4:2000: "Road Vehicles — Keyword protocol 2000 for diagnostic systems — Part 4: Requirements for emission-related systems";

(f) ISO 15765-4:2011: "Road vehicles — Diagnostics on Controller Area Network (CAN) — Part 4: Requirements for emissions-related systems", dated 1 November 2001;

(g) ISO 22901-2:2011: "Road vehicles — Open diagnostic data exchange (ODX) — Part 2: Emissions-related diagnostic data".

3.9. Test equipment and diagnostic tools needed to communicate with OBD systems shall meet or exceed the functional specification in ISO 15031-4:2005: "Road vehicles — Communication between vehicle and external test equipment for emissions-related diagnostics — Part 4: External test equipment".

3.10. Basic diagnostic data (as specified in paragraph 3.) and bi-directional control information shall be provided using the format and units described in ISO 15031-5:2011 "Road vehicles — Communication between vehicle and external test equipment for emissions-related diagnostics — Part 5: Emissions-related diagnostic services" and shall be available using a diagnostic tool meeting the requirements of ISO 15031-4:2005.

3.10.1. The vehicle manufacturer shall provide the approval authority with details of any diagnostic data, e.g. PIDs, OBD monitor IDs, Test IDs not specified in ISO 15031-5:2011 but relating to this Regulation.

3.11. When a fault is registered, the manufacturer shall identify the fault using an appropriate diagnostic trouble code consistent with those in Section 6.3. of ISO 15031-6:2010 "Road vehicles — Communication between vehicle and external test equipment for emissions-related diagnostics — Part 6: Diagnostic trouble code definitions" relating to "emission related system diagnostic trouble codes". If this is not possible, the manufacturer may use the diagnostic trouble codes in Sections 5.3. and 5.6. of ISO DIS 15031-6:2010. Alternatively, diagnostic trouble codes may be compiled and reported according to ISO14229:2006. The diagnostic trouble codes shall be fully accessible by standardised diagnostic equipment complying with paragraph 3.9.

3.11.1. The vehicle manufacturer shall provide to a national standardisation body the details of any emission-related diagnostic data, e.g. PIDs, OBD monitor IDs, Test IDs not specified in ISO 15031-5:2011 or ISO14229:2006, but relating to this gtr.

3.12. The connection interface between the vehicle and the diagnostic tester shall be standardised and meet all the requirements of ISO [DIS] 19689 "Motorcycles and Mopeds — Communication between vehicle and external equipment for diagnostics — Diagnostic connector and related electrical circuits, specification and use" or ISO 15031-3:2004 "Road vehicles — Communication between vehicle and external test equipment for emissions-related diagnostics — Part 3: Diagnostic connector and related electric circuits: specification and use". The preferred installation position is under the seating position. Any other position of the diagnostic connector shall be subject to the approval authority's agreement and be readily accessible by service personnel but protected from tampering by non-qualified personnel.

The position of the connection interface shall be clearly indicated in the user manual.

3.13. The vehicle manufacturer may use an alternative connection interface upon request. Where an alternative connection interface is used, the vehicle manufacturer shall provide an adapter enabling connection to a generic scan tool. Such an adapter shall be provided in a non-discriminating manner to all independent operators.

4. Access to OBD information

4.1. Applications for approval or its amendments shall be accompanied by the repair information concerning the vehicle OBD system. This information shall enable manufacturers of replacement or retrofit components to make the parts they manufacture compatible with the vehicle OBD system, with a view to fault-free operation assuring the vehicle user against malfunctions. Similarly, such repair information shall enable the manufacturers of diagnostic tools and test equipment to make tools and equipment that provide for the effective and accurate diagnosis of vehicle control systems.

4.2. Upon request, the vehicle manufacturer shall make the repair information on the OBD system available to any interested components, diagnostic tools or test equipment manufacturer on a non-discriminatory basis:

4.2.1. A description of the type and number of preconditioning cycles used for the original approval of the vehicle;

4.2.2. A description of the type of the OBD demonstration cycle used for the original approval of the vehicle for the component monitored by the OBD system;

4.2.3. A comprehensive document describing all sensed components with the strategy for fault detection and MI activation (fixed number of driving cycles or statistical method), including a list of relevant secondary sensed parameters for each component monitored by the OBD system and a list of all OBD output codes and format used (with an explanation of each) associated with individual emission related powertrain components and individual non-emission related components, where monitoring of the component is used to determine MI activation.

4.2.4. This information may be provided in the form of a table, as follows:

Table 1
Template OBD information list

Component	*Diagnostic trouble code*	*Monitoring strategy*	*Fault detection criteria*	*MI activation criteria*	*Secondary parameters*	*Preconditioning*	*Demonstration test*	*Default mask*
Catalyst	P0420	Oxygen sensor 1 and 2 signals	Difference between sensor 1 and sensor 2 signals	3rd cycle	Engine speed, engine load, A/F mode, catalyst temperature	Two type I cycles	Type I	None

4.2.5. If an approval authority receives a request from any interested components, diagnostic tools or test equipment manufacturer for information on the OBD system of a vehicle that has been type approved by that type approval authority to a previous version of this Regulation (if any),

(a) That approval authority shall, within 30 days, ask the manufacturer of the vehicle in question to make available the information required in paragraphs 3.1. and 3.2.;

(b) The vehicle manufacturer shall submit this information to that approval authority within two months of the request;

(c) That approval authority shall transmit this information to the other Contracting Parties' approval authorities and shall attach this information to the vehicle approval information.

4.2.6. Information can be requested only for replacement or service components that are subject to approval or for components that form part of a system subject to approval.

4.2.7. The request for repair information shall identify the exact specification of the vehicle model for which the information is required. It shall confirm that the information is required for the development of replacement or retrofit parts or components or diagnostic tools or test equipment.

4.2.8. Access to vehicle security features used by authorised dealers and repair shops shall be made available to independent operators under protection of security technology according to the following requirements:

(a) Data shall be exchanged ensuring confidentiality, integrity and protection against replay;

(b) The standard https//ssl-tls (RFC4346) shall be used;

(c) Security certificates in accordance with ISO 20828 shall be used for mutual authentication of independent operators and manufacturers;

(d) The independent operator's private key shall be protected by secure hardware.

4.2.8.1. The Contracting Parties will specify the parameters for fulfilling these requirements according to the state of the art.

4.2.8.2. The independent operator shall be approved and authorized for this purpose on the basis of documents demonstrating that they pursue a legitimate business activity and have not been convicted of relevant criminal activity.

Annex 2

Minimum monitoring requirements for an On-Board Diagnostic (OBD) system stage I

1. Subject matter

The following minimum monitoring requirements shall apply for OBD systems complying with the requirements of OBD stage I regarding electric circuit diagnostics.

2. Scope and monitoring requirements

If fitted, the following listed sensors and actuators shall be monitored for electric circuit malfunctions.

2.1. A Contracting Party may choose to apply one of the following grades of OBD stage I:

Table 1
Scope of grades A, B and C of OBD stage I

	Grade A	*Grade B*	*Grade C*
Table 2 of this annex	yes Limited to sensor circuits only, items Nos. 2, 4, 5, 10, 11, 12, 15, 17, 18, 21. Sensor circuits are to be monitored for electric circuit malfunctions, open/short circuit failures.	yes	yes
Any other sensor or actuator circuit declared by the manufacturer	yes	yes	yes
Annex 3	no	no	yes
OBD fail thresholds set out in domestic legislation	no	no	yes

2.2. At a minimum the monitored devices with mandatory circuit diagnostics shall be the following:

Table 2

Overview of devices (if fitted) to be monitored in OBD stage 1

2	Device circuits		Circuit continuity			Circuit rationality				Comment No.
		Level, refer to 2.3	Circuit High	Circuit Low	Open circuit	Out of Range	Performance / Stuck/Slow	Signal stuck	Device operational / Device present	
1	Control module (ECU / PCU) internal error	3							1	(1)
Sensor (input to control units)										
1	Accelerator (pedal / handle) position sensor	1 & 3	1	1	1	1	1	1		(2)
2	Barometric pressure sensor	1	1	1	1					
3	Camshaft position sensor	3							1	
4	Crankshaft position sensor	3							1	
5	Engine coolant temperature sensor	1	1	1	1					
6	Exhaust control valve angle sensor	1	1	1	1					
7	Exhaust gas recirculation sensor	1 & 3	1	1	1					
8	Fuel rail pressure sensor	1	1	1	1					
9	Fuel rail temperature sensor	1	1	1	1					
10	Gear shift position sensor (potentiometer type)	1	1	1	1					
11	Gear shift position sensor (switch type)	3							1	
12	Intake air temperature sensor	1	1	1	1					
13	Knock sensor (Non-resonance type)	3							1	

No	Device circuits	Circuit continuity				Circuit rationality				Connector No
		Level, refer to 2.3	Circuit High	Circuit Low	Open Circuit	Out of Range	Performance / Stuckability	Signal stuck	Device operational / Device present	
14	Knock sensor (Resonance type)	3					1			
15	Manifold absolute pressure sensor	1	1	1	1					
16	Mass air flow sensor	1	1	1	1					
17	Engine oil temperature sensor	1	1	1	1					
18	O_2 exhaust sensor (binary / linear) signals	1	1	1	1					
19	Fuel (high) pressure sensor	1	1	1	1					
20	Fuel storage temperature sensor	1	1	1	1					
21	Throttle position sensor	1 & 3	1	1	1	1	1	1		(2)
22	Vehicle speed sensor	3							1	(3)
23	Wheel speed sensor	3							1	(3)
Actuators (output control units)										
1	Evaporative emission system purge control valve	2		1						
2	Exhaust control valve actuator (motor driven)	3							1	
3	Exhaust gas recirculation control	3								
4	Fuel injector	2		1					1	(4)
5	Idle air control system	1	1	1	1				1	(4)
6	Ignition coil primary control circuits	2		1					1	(4)
7	O_2 exhaust sensor heater	1	1	1	1				1	(4)
8	Secondary air injection system	2		1					1	(4)

No	Device circuits		Circuit continuity			Circuit rationality				Comment No.
		Level, refer to 2.3.	Circuit High	Circuit Low	Open Circuit	Out of Range	Performance / Plausibility	Signal stuck	Device operational / Device present	
9	Throttle by wire actuator	3		1					1	(4)

(1) Only in case of an activated limp-home mode or if a throttle by wire system is fitted.

(2) If there is only one APS or TPS fitted, APS or TPS circuit rationality monitoring is not mandatory.

(3) Only if used as input to ECU / PCU with relevance to environmental performance or when the OBD system fault triggers a limp-home mode.

(4) Derogation allowed if manufacturer requests, level 3 instead, actuator signal present only without indication of symptom.

2.2. If there are more of the same device types fitted on the vehicle listed in Table 2, those devices shall be separately monitored and reported in case of malfunctions. If a malfunction is marked with "1" in Table 2 it shall mean that monitoring is mandatory for OBD stage I.

2.3. Sensors and actuators shall be associated with a specific diagnostic level that defines which type of diagnostic monitoring shall be performed as follows:

2.3.1. Level 1: sensor/actuator of which at least two circuit continuity symptoms can be detected and reported (i.e. short circuit to ground, short circuit to power and open circuit).

2.3.2. Level 2: sensor/actuator of which at least one circuit continuity symptom can be detected and reported (i.e. short circuit to ground, short circuit to power and open circuit).

2.3.3. Level 3: sensor/actuator of which at least one symptom can be detected, but not reported separately.

2.4. Two out of three symptoms in circuit continuity as well as in circuit rationality monitoring diagnostic may be combined, e.g. circuit high or open and low circuit / high and low or open circuit / signal out of range or circuit performance and signal stuck.

2.5. Exemptions regarding detection

Exemption from detecting certain electric circuit monitoring symptoms may be granted if the manufacturer can demonstrate to the satisfaction of the approval authority that the only feasible monitoring strategy would negatively affect vehicle safety or driveability in a significant way.

2.6. Exemption regarding OBD emission verification tests (test type VIII)

At the request of the manufacturer and based on a technical justification to the satisfaction of the approval authority, certain OBD monitors listed in Table 2 may be exempted from test type VIII emission verification tests referred to in Annex 3 under the condition that the manufacturer can demonstrate to the approval authority that:

2.6.1. The malfunction indicator fitted to the vehicle is activated when the malfunction listed in Table 2 occurs:

2.6.1.1. During the same key cycle and:

2.6.1.2. Immediately after expiration of a limited time delay (300 s or less) in that same key cycle; or

2.6.2. Monitoring of some of the items listed in Table 2 is physically not possible and a deficiency has been granted for this incomplete monitor. The comprehensive, technical justification why such an OBD monitor cannot run shall be added to the information folder.

2.7. Exemptions grade A

2.7.1. Grade A on-board diagnostic systems are exempted from the requirements set-out in:

(a) Paragraphs 3.1. and 3.2. of Annex 1.

2.8. Grade A specific test requirements

2.8.1. If the OBD parameter requires the engine to be driven for MI activation, the vehicle shall be driven as per driving cycle prescribed in gtr No. 2, or any driving cycle prescribed by manufacturer including key On / Off cycles. The test vehicle can be considered meeting circuit discontinuity testing when the MI activates within a maximum of 10 driving cycles.

2.8.2. If the OBD parameter does not require the vehicle to be driven for MI activation, the test vehicle can be considered meeting circuit discontinuity testing for the tested OBD fault mode, if the MI activates under the conditions described in paragraphs 2.6.1., 2.6.1.1. and 2.6.1.2.

Annex 3

Option, test type VIII, on-board diagnostic environmental verification test

1. Introduction

1.1. This annex describes the procedure for type VIII testing, On-Board Diagnostics (OBD) environmental verification testing, which a Contracting Party may require for the approval of a vehicle complying with OBD stage I requirements. Test type VIII environmental verification testing is optional and depends upon the grade of the OBD stage I set out in Table 1 of Annex 2 and opted by the Contracting Party. The procedure describes methods for checking the function of the OBD system on the vehicle by simulating failure of emission-relevant components in the powertrain management system and emission-control system.

1.2. The manufacturer shall make available the defective components or electrical devices to be used to simulate failures. When measured over the appropriate test type I cycle, such defective components or devices shall not cause the vehicle emissions to exceed by more than 20 percent the OBD emission thresholds if the Contracting Party applies these fail thresholds as MI activation performance criteria. For electric failures (short/open circuit) the emissions may exceed the OBD emission thresholds by more than 20 per cent.

1.3. When the vehicle is tested with the defective component or device fitted, the OBD system shall be approved if the malfunction indicator is activated. The system shall also be approved if the indicator is activated below the OBD emission thresholds if the Contracting Party applies these fail thresholds as MI activation performance criteria.

2. OBD stage I

The test procedures in this annex shall be prescribed by those Contracting Parties that have decided to apply explicit OBD fail thresholds which are used as MI activation performance criteria.

3. Description of tests

3.1. The OBD system shall indicate the failure of any of the devices in accordance with Annex 2.

3.2. The test type I data in the template for a test report according to the template set out in gtr No. 2, including the used dynamometer settings and applicable emission laboratory test cycle, shall be provided for reference.

3.3. The list with PCU / ECU malfunctions shall be provided:

3.3.1. For each malfunction that leads to the OBD emission thresholds, if the Contracting Party applies these fail thresholds as MI activation performance criteria, in both non-defaulted and defaulted driving mode being exceeded. The emission laboratory test results shall be reported in those additional columns in the format of the information document referred to in Annex 5;

3.3.2. For short descriptions of the test methods used to simulate the emission-relevant malfunctions, as referred to in paragraph 4.

4. OBD environmental test procedure

4.1. The testing of OBD systems consists of the following phases:

4.1.1. Simulation of malfunction of a component of the powertrain management or emission-control system;

4.1.2. Preconditioning of the vehicle (in addition to the preconditioning specified in gtr No. 2) with a simulated malfunction that will lead to the OBD emission thresholds being exceeded, if the Contracting Party applies these OBD fail thresholds as MI activation performance criteria;

4.1.3. Driving the vehicle with a simulated malfunction over the applicable type I test cycle and measuring the tailpipe emissions of the vehicle;

4.1.4. Determining whether the OBD system reacts to the simulated malfunction and alerts the vehicle driver to it in an appropriate manner.

4.2. Alternatively, at the request of the manufacturer, malfunction of one or more components may be electronically simulated in accordance with the requirements laid down in paragraph 8.

4.3. Manufacturers may request that monitoring take place outside the type I test cycle if it can be demonstrated to the approval authority that the monitoring conditions of the type I test cycle would be restrictive when the vehicle is used in service.

4.4. For all demonstration testing, the Malfunction Indicator (MI) shall be activated before the end of the test cycle.

5. Test vehicle and fuel

5.1. Test vehicle

The aged, test parent vehicle(s) or a new vehicle fitted with defective components or electrical devices shall meet the propulsion unit family requirements laid down in Annex 4 and relevant requirements laid down in gtr No. 2. The distance accumulation and ageing test procedure is at the discretion of the Contracting Party.

5.2. The manufacturer shall set the system or component for which detection is to be demonstrated at or beyond the criteria limit prior to operating the vehicle over the emissions test cycle appropriate for the classification of the vehicle. To determine correct functionality of the diagnostic system, the test vehicle shall then be operated over the appropriate type I test cycle at the discretion of the Contracting Party.

5.3. Test fuel

The reference fuel to test the vehicle shall be specified by the Contracting Party and be of the same specification as the reference fuel used to conduct the type I tailpipe emissions after cold start. The selected fuel type shall not be changed during any of the test phases. Where LPG or NG/biomethane for alternative fuel vehicles are used as a fuel, the engine may be started on petrol and switched to LPG or NG/biomethane (automatically and not by the driver) after a pre-determined period of time.

6. Test temperature and pressure

6.1. The test temperature and ambient pressure shall meet the requirements of the specified type I test by the Contracting Party.

7. Test equipment

7.1. Chassis dynamometer

The chassis dynamometer shall meet the requirements of gtr No. 2.

8. OBD environmental verification test procedures

8.1. The operating test cycle on the chassis dynamometer shall meet the test type I requirements as specified by the Contracting Party.

8.2. Vehicle preconditioning

8.2.1. According to the propulsion type and after introduction of one of the failure modes referred to in paragraph 8.3., the vehicle shall be preconditioned by driving at least two consecutive appropriate type I tests. For vehicles equipped with a compression ignition engine, additional preconditioning of two appropriate type I test cycles is permitted.

8.2.2. At the request of the manufacturer, alternative preconditioning methods may be used.

8.3. Failure modes to be tested

8.3.1. For vehicles equipped with a Positive Ignition (PI) engine:

8.3.1.1. Electrical disconnection of any other emission-related component connected to a powertrain control unit / engine control unit (if active on the selected fuel type) in the scope of Annex 2;

8.3.1.2. Electrical disconnection of the electronic evaporative purge control device (if equipped and if active on the selected fuel type). For this specific failure mode, the type I test need not be performed.

8.3.2. For vehicles equipped with a Compression Ignition (CI) engine:

8.3.2.1. Electrical disconnection or shorted circuit of any electronic fuel quantity and timing actuator in the fuelling system;

8.3.2.2. Electrical disconnection or shorted circuit of any other relevant component connected to control computer of the powertrain that triggers a limp-home mode;

8.3.2.3. The manufacturer shall take appropriate steps to demonstrate that the OBD system will indicate a fault when one or more of the faults occur listed in Annex 2.

8.3.4. It is left to the discretion of a Contracting Party to define and apply MI activation performance criteria and to set out the performance conditions to activate and deactivate the MI in its domestic legislation.

8.4. OBD system environmental verification tests

8.4.1. Vehicles fitted with Positive Ignition (PI) engines:

8.4.1.1. After vehicle preconditioning in accordance with paragraph 8.2., the test vehicle is driven over the appropriate type I test.

8.4.1.2. The malfunction indicator shall activate before the end of this test under any of the conditions given in paragraphs 8.4.1.3. and 8.4.1.4. The approval authority may substitute those conditions with others in accordance with paragraph 8.4.1.4. However, the total number of failures simulated shall not exceed four for the purpose of approval.

For bi-fuelled gas vehicles, both fuel types shall be used within the maximum of four simulated failures at the discretion of the approval authority.

8.4.1.3. Electrical disconnection of the electronic evaporative purge control device (if equipped and if active on the selected fuel type);

8.4.1.4. Electrical disconnection of any other component connected to a powertrain control unit / engine control unit / drive train control unit in the scope of Annex 2.

8.4.2. Vehicles fitted with Compression Ignition (CI) engines:

8.4.2.1. After vehicle preconditioning in accordance with paragraph 8.2., the test vehicle is driven in the applicable type I test.

The malfunction indicator shall activate before the end of this test. The approval authority may substitute those conditions by others in accordance with paragraph 8.4.2.2. However, the total number of failures simulated shall not exceed four for the purposes of approval.

8.4.2.2. Electrical disconnection of any other component connected to a powertrain control unit / engine control unit / drive train control unit in the scope of Annex 2.

Annex 4

Propulsion unit family definition with regard to on-board diagnostics

1. A vehicle in the scope of this gtr may continue to be regarded as belonging to the same vehicle propulsion family with regard to on-board diagnostics provided that the vehicle parameters below are identical and remain within the prescribed and declared tolerances.

2. A representative parent vehicle shall be selected within the boundaries set by the classification criteria laid down in Table 1 of paragraph 3.

3. The following propulsion family classification criteria shall apply:

Table 1

Classification criteria propulsion family with regard to on-board diagnostics

	Classification criteria description	*OBD stage 1*
1.	**Vehicle**	
1.1.	category; Note: Two-wheeled motorcycles and two-wheeled motorcycles with sidecars are considered to be of the same family.	X
1.2.	sub-category;	X
1.3.	the inertia of a vehicle variant(s) or version(s) within two inertia categories above or below the nominal inertia category;	X
1.4.	overall gear ratios (+/- 8%).	X
2.	**Propulsion family characteristics**	
2.1.	number of engines;	X
2.2.	number of cylinders of the combustion engine;	X
2.3.	engine capacity (+/- 30 %) of the combustion engine;	X
2.4.	number and control (variable cam phasing or lift) of combustion engine valves;	X
2.5.	mono-fuel / bi-fuel / flex-fuel HCNG / multi-fuel;	X
2.6.	fuel system (carburettor / scavenging port / port fuel injection / direct fuel injection / common rail / pump-injector / other);	X
2.7.	fuel storage[1];	X

	Classification criteria description	*OBD stage 1*
2.8.	type of cooling system of combustion engine;	X
2.9.	combustion cycle (PI / CI / two-stroke / four-stroke / other);	X
2.10.	intake air system (naturally aspirated / charged (turbocharger / super-charger) / intercooler / boost control) and air induction control (mechanical throttle / electronic throttle control / no throttle).	X
3.	**Pollution control system characteristics**	
3.1.	operation principle of cold start or starting aid device(s);	X
3.2.	activation time of cold-start or starting aid device(s) and /or duty cycle (only limited time activated after cold start / continuous operation);	X
3.3.	propulsion unit (not) equipped with O_2 sensor for fuel control;	X
3.4.	O_2 exhaust sensor type(s);	X
3.5.	operation principle of O_2 exhaust sensor (binary / wide range / other);	X
3.6.	O_2 exhaust sensor interaction with closed-loop fuelling system (stoichiometry / lean or rich operation).	X

Explanatory note:

(1) Only for vehicles equipped with storage for gaseous fuel

Annex 5

Administrative provisions

1. The vehicle manufacturer shall fill out the information and submit to the approval authority with regard to functional on-board diagnostics and test type VIII according to the following template. The information is depending on the choices and preferred alternative grades from the Contracting Party as laid down in Table 1 of Annex 2.

2. Where documents, diagrams or long descriptions are required the vehicle manufacturer shall attach those as a separate file, appropriately marked in a clear and understandably system and the marking shall be written / typed for all sheets in the space provided.

The following data shall be provided by the vehicle manufacturer.

2.1. On-board diagnostics (OBD) functional requirements

2.1.1. *OBD system general information*

2.1.1.1. Written description or drawing of the Malfunction Indicator (MI);

2.1.2. *List and purpose of all components monitored by the OBD system:*

2.1.2.1. Written description (general working principles) for all OBD stage I circuit (open circuit, shorted low and high, rationality) and electronics (PCU / ECU internal and communication) diagnostics which triggers a default mode in case of fault detection;

2.1.2.2. Written description (general working principles) for all OBD stage I diagnostic functionality triggering any operating mode which triggers a limp-home mode in case of fault detection;

2.1.2.3. Written description of the communication protocol(s) supported;

2.1.2.4. Physical location of diagnostic-connector (add drawings and photographs);

2.1.2.5. Other components than the ones listed in Table 2 of Annex 2 monitored by the OBD system;

2.1.2.6. Criteria for MI activation (fixed number of driving cycles or statistical method);

2.1.2.7. List of all OBD output codes and formats used (with explanation of each);

2.1.2.8. OBD compatibility for repair information

The following additional information shall be provided by the vehicle manufacturer to enable the manufacture of OBD-compatible replacement or service parts, diagnostic tools and test equipment;

2.1.2.9. A description of the type and number of the pre-conditioning cycles used for the original approval of the vehicle if the Contracting party applies grade B plus opts for emission verification in accordance with Annex 3;

2.1.2.10. A comprehensive document describing all sensed components concerned with the strategy for fault detection and MI activation (fixed number of driving cycles or statistical method). This shall, include a list of relevant

secondary sensed parameters for each component monitored by the OBD system. The document shall also list all OBD output codes and formats (with an explanation of each) used in association with individual emission-related powertrain components and individual non-emission-related components, where monitoring the component is used to determine MI activation. This will contain, in particular, a comprehensive explanation for the data given in service $05 Test ID $ 21 to FF;

2.1.2.11. The information required in paragraphs 2.1.2.1. to 2.1.2.10. may be provided in table form as described in the following table:

Table 1
Example OBD fault-code overview list

Component	*Diagnostic trouble code*	*Monitoring strategy*	*Fault detection criteria*	*MI activation criteria*	*Secondary parameters*	*Preconditioning*	*Demonstration test*
Intake air temp sensor open circuit	P0xx xxzz	Comparison with temperature model after cold start	> 20 degrees difference between measured and modelled intake air temperature	3rd cycle	Coolant and intake air temperature sensor signals	Two type I cycles	Type I if Contracting Party applies MI performance criteria

2.1.2.12. Description of Electronic Throttle Control (ETC) diagnostic trouble codes:

2.1.2.13. Description of default modes and strategies in case of ETC failure:

2.1.2.14. Communication protocol information

The following information shall be referenced to a specific vehicle make, model and variant, or identified using other workable definitions such as the Vehicle Identification Number (VIN) or vehicle and systems identification:

2.1.2.14.1. Any protocol information system needed to enable complete diagnostics in addition to the standards prescribed in paragraph 3.8. of Annex 1., such as additional hardware or software protocol information, parameter identification, transfer functions, "keep alive" requirements, or error conditions;

2.1.2.14.2. Details of how to obtain and interpret all diagnostic trouble codes not in accordance with the standards prescribed in paragraph 3.11. of Annex 2:

2.1.2.14.3. A list of all available live data parameters including scaling and access information;

2.1.2.14.4. A list of all available functional tests including device activation or control and the means to implement them;

2.1.2.14.5. Details of how to obtain all component and status information, time stamps, pending DTC and freeze frames;

2.1.2.14.6. Resetting adaptive learning parameters, variant coding and replacement component setup, and customer preferences;

2.1.2.14.7. PCU / ECU identification and variant coding;

2.1.2.14.8. Details of how to reset service lights;

2.1.2.15. Location of diagnostic connector and connector details;

2.1.2.16. Engine code identification;

2.1.2.17. Test and diagnosis of OBD monitored components;

2.1.2.17.1. A description of tests to confirm its functionality, at the component or in the harness;

2.1.2.17.2. Test procedure including test parameters and component information;

2.1.2.17.3. Connection details including minimum and maximum input and output and driving and loading values;

2.1.2.17.4. Values expected under certain driving conditions including idling;

2.1.2.17.5. Electrical values for the component in its static and dynamic states;

2.1.2.17.6. Failure mode values for each of the above scenarios;

2.1.2.17.7. Failure mode diagnostic sequences including fault trees and guided diagnostics elimination.

2.1.3. On-board diagnostics environmental test type VIII requirements

2.1.3.1. Details of test vehicle(s), its powertrain and pollution-control devices explicitly documented and listed, emission test laboratory equipment and settings.